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ABSTRACT

Many low-cost and no-cost modifications to computers would greatly increase the number of disabled individuals who could use standard computers without requiring custom modifications, and would increase the ability to attach special input and output systems. The purpose of the Guidelines is to provide an awareness of these access problems and a focal point for listing possible solutions. Section I provides an overview of disability types and the major impacts that each disability has on computer use. Section II contains a listing of problem areas and possible solutions, arranged by the part of the computer involved, including operating systems, keyboards, display screens, other output devices, mechanical design, and documentation. The Executive Summary contains a chart summarizing the problems, the populations affected, a relative priority, possible solution strategies, and the impact/benefit of such adaptations or modifications on/to the mass market for the computer. A summary listing of design ideas is presented in three categories: design features to increase the number of people who can use an unmodified computer; design features to facilitate the connection of special accessories or programs needed by more severely involved persons; and to design features to facilitate the use of computers as special devices, such as portable communication aids. (JDD)

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GUIDELINES

FOR THE DESIGN OF COMPUTERS AND INFORMATION PROCESSING SYSTEMS

TO INCREASE THEIR ACCESS BY PERSONS WITH DISABILITIES

VERSION 2.0

APRIL 1986

A PRODUCT OF THE GUIDELINES TASK FORCE
OF THE GOVERNMENT-INDUSTRY INITIATIVE
ON ACCESS TO COMPUTER SYSTEMS BY DISABLED PERSONS

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EXECUTIVE SUMMARY

FOR

GUIDELINES

FOR THE DESIGN OF COMPUTERS AND INFORMATION PROCESSING SYSTEMS

TO INCREASE THEIR ACCESS BY PERSONS WITH DISABILITIES

VERSION 2.0

APRIL 1986

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EXECUTIVE SUMMARY

OVERVIEW

- A significant portion of our population have disabilities, have acquired at birth or through accident, illness, which currently prevent them from using standard microcomputers and software.

- Many low-cost and no-cost modifications to computers would greatly increase the number of individuals who could use standard computers without requiring modification.

- In addition, other modifications would greatly increase the ability to attach special input and output systems, further increasing the number of individuals who can use standard computers and software, as well as lowering the cost for such modifications.

- Most of these modifications fall in the low-cost or no-cost range, and have direct benefit to the mass market users as well.

- The current direction in which computer systems are evolving will automatically encompass many or most of the required features and capabilities if they are implemented properly.

- In discussions with engineers and designers within the major computer companies, the predominant response has been that many of the desired changes could have been included in the design of computers originally if the developers had been aware of the need for and impact of such changes.

- The purpose of these Guidelines is to provide an awareness of the different types of problems as well as a focal point for listing suggested possible solution strategies. The content of this Guidelines document reflects the combined input of industry, researchers and consumers.

DISABILITY TYPES AND BARRIERS

- Physically disabled individuals face their primary difficulty in inputting to computers, or handling disk media. Individuals in this group include individuals with congenital disabilities, spinal cord injuries, and progressive diseases, as well as individuals who may be only be without the use of a hand or arm on either a temporary or permanent basis. Adding some options to the keyboard handling routines would allow many individuals to

directly access the computer. Providing means to connect "alternate keyboards" would provide access to individuals with more severe disabilities.

- Visually impaired individuals have their primary difficulties with the output display. This group includes individuals who have failing vision as well as those who are blind. The primary solution strategies involve providing a mechanism to connect alternative display or display translator devices to the computer.

- Hearing impaired and deaf individuals currently have little difficulty in using computers. Visual redundancy of auditory clicks and tones would be helpful. The primary concern is ensuring that future voice output information is provided in a redundant form that hearing impaired or deaf individuals can also understand.

- Access to systems for individuals with cognitive impairments refers mostly to public access information or transaction systems. Solutions strategies are basically software-based, and would involve the use of simple language and straightforward displays.

SUMMARY CHART

Attached is a chart summarizing the various problems, the populations affected, a relative priority, possible solution strategies, and the impact/benefit of such adaptations/modifications or such features to the mass market for the computer.

Summary Chart

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Page number in full Guidelines	Problem Title	Types of Individuals Affected	Priority	Possible Design Approaches	Impact on Mass Market
1.1	**Alternate Input** Inability to connect alternate input devices (Item 1.1)	-Physically handicapped (moderate/severe) -Blind	High	-Provide an entry point in the operating system that is treated exactly like the keyboard (mouse, etc.) even at boot time. -Increase standardization of keyboard connectors. -Provide a standard or semi-standard alternate access connector that treats input exactly the same as the standard input device.	-Increased ability of third-party vendors to produce alternate input devices especially for new models.
1.2	**Nested Routines** Inability to nest access routines in the computer (Item 1.2)	-Physically handicapped -Blind	High	-Provide a point in the operating system where one program can inject keystrokes or other inputs to another program which will treat it precisely like input from keyboards, mice, etc., under all conditions. -Provide an "input" window capability as well as active and background windows.	-Has wide-ranging implications for specialized input techniques or processing algorithms.
2.1	**Shift/Ctrl Keys** Inability to hold down a shift or control key and another key at the same time (Item 2.1)	-People with only one arm (permanent or temporary) - People who use a single finger, headstick, etc..	High	-Provide an optional tri-state latching of the shift, control, and similar keys. Tri-state latching can be built into the software or firmware of the computer or keyboard.	-Easily called up for disabled at the options of the user, with auto turn off for able-bodied users. -Able-bodied users may find it convenient when using the one hand to handle books or keep their place in charts.
2.2	**Keyboard Position** Inability to position the keyboard (Item 2.2)	-Physically handicapped (especially individuals in wheelchairs)	Medium-high	-Detached or detachable keyboard. -For non-detachable keyboards (including portables), provide a keyboard connector on the computer so that a separate keyboard can be connected. -Wireless keyboard.	-This facilitates access and comfort of users.
2.3	**Keyguard** Inability to accommodate a keyguard (Item 2.3)	-Physically handicapped	Medium	-Provide space inside case (laptops and portables). -Provide mounting points on the keyboard. -Provide a keyguard as a special accessory.	-This would facilitate special overlays as well as keyboard masks for use in special applications or with young children.
2.4	**Finding Keys** Difficulty in finding keys without looking (Item 2.4)	-Blind -Touch typists	Medium	-Place nibs either either on the top or the front edge of strategic keys such as the D, K, BACKSPACE, DELETE, and ESCAPE keys. -Standardize the positions of more keys, especially BACKSPACE, DELETE, and ESCAPE.	-It would be easier for touch typists to use peripheral keys.
2.5	**Seeing Keys** Inability to see the labeling on keys (Item 2.5)	-Low vision -Elderly -Individuals with movement disorders who have difficulty holding their head still	Medium	-Use larger letters on the keys. -Use higher contrast colors.	-Reduces eyestrain. -Reduced visual complexity of the keys may be less threatening to non-technophiles.
2.6	**Key Repeat** Unwanted multiple letters caused by the key repeat feature (Item 2.6)	-Physically handicapped (with slow release times) -Young children	Medium	-Have user adjustable repeat key rate and start-up (should be always available).	-Would facilitate use of systems by young children.
2.7	**Key Delay** Unwanted keys due to lack of delay activation time (Item 2.7)	-Physically handicapped (with erratic hand motion) -People with hand tremors -Young children	Medium-low	-Have a user adjustable activation delay before a keystroke is accepted (should be always available).	-Could facilitate use of systems by young children.
4.1	**Display Size** Information on standard display for the computer is too small (Item 4.1)	-Low vision -Elderly	High	-Make the video signal available externally so that larger displays can be connected. -Use a larger screen as part of the computer system. -Provide a built-in zoom capability.	-Larger, clearer displays are easier for everyone to use. -External access to the video signal is part of open architecture. -Facilitates connection of larger displays and display printers as well as special purpose video processors.
4.2	**Special Displays** Display video information is not provided externally for use by special display (Item 4.2)	-Blind -Low vision	High	-Export a bit image of the screen of the screen for capture and reprocessing (especially for LCD displays). -Export the video signal for video image capture and reprocessing (see also 4.1). -Export the character content of the screen.	-As another extension of the open architecture concept, this allows for easier connection of alternate resolution displays and display printers, etc., for mass market.
4.3	**Display Position** Inability to position the display for easier viewing (Item 4.3)	-Visually impaired -Physically handicapped	Medium	-Separate or movable display. -Connector to attach a movable display.	-Greater comfort and lower fatigue. -Better adaptability to individual physical characteristics of users.

Summary Chart

Version 2.0 April 1986

Page number in full Guidelines	Problem Title	Types of Individuals Affected	Priority	Possible Design Approaches	Impact on Mass Market
4.4	Color-encoded Info Inability to distinguish some information presented through color (Item 4.4)	-Color Blind	Medium	-Be sure that all information that is contained in the color coded portions of the display information is also presented (or can be presented) in another way (through capitalization, highlighting, position, etc.). -User can select colors used on display.	-Redundant presentation of information facilitates speed in comprehension by all users.
5.1	Auditory Output Inability to handle information presented auditorially (Item 5.1)	-Deaf -Hearing impaired -Elderly	High	-All information provided auditorially is provided in a redundant fashion visually. -LED mounted prominently on the keyboard or display which could light up in parallel with the computer speaker (at option of the user).	-Facilitates use of computers in noisy environments. -Facilitates use of computers where computers are located immediately adjacent to each other, and origin of the sound may be ambiguous.
5.2	Modem Speech Inability to effectively use new speech capabilities of computers with their built-in modems (Item 5.2)	-Speech impaired -Blind	Medium-low	-Capability to direct speech through auto-dial feature in built-in modem.	-Opens up a wide variety of applications in stored speech messaging and combination text and speech capabilities. -Facilitates personal messaging systems and timed message delivery systems.
6.1	Disk Drives Inability to insert and remove disks (and other media) (Item 6.1)	-Physically handicapped	Medium-high	-Frontal access to disk drives. -Avoid twist lock mechanisms. -Use low-effort mechanisms operable by a stick in one's mouth. -Use 3-1/2" disks (more stiff). -Disk drives that "pop" the disk out. -Self-channeling disk drive openings. -Hard disk loadable software. -Separate disk drive option.	-Easier, more convenient disk drive operation by everyone.
6.2	Power Switch Inability to operate power switch (Item 6.2)	-Physically handicapped -Blind	Medium	-Front mounted power switches. -Allow it to be operated with a push motion (mouthstick, etc.) -Make it tactilely distinct and not easily activated (though not requiring great strength). -Have a computer which never completely turns off and can be activated, put to sleep, and reset from the keyboard or alternate keyboards.	-Easier to find the power switch on mass market access systems. -Provides greater flexibility in placement of computer components, since it is more difficult to accidentally block access to the switch.
6.3	Latches Inability to open up and collapse computers (portable/laptop) (Item 6.3)	-Physically handicapped	Medium-high	-Design systems that do not require simultaneous release of two latches. -A latch setting that allows the system to be opened and closed without locking shut each time.	-Easier use of computer; easier opening and closing with one hand.
6.4	Attachment Means Inability to attach things to the computer (Item 6.4)	-All types of disabilities	Medium	-Pre-tapped holes on the bottom (or back) of the computer to bolt the computer to a laptray or to bolt special accessories to the computer.	-Facilitates security mounting. -OEM-VAR construction of special applications equipment.
6.5	Control Knobs Inability to operate controls requiring twist action (Item 6.5)	-Physically handicapped (especially those who use a mouthstick or headstick)	Medium	-Use thumbwheel controls. -Use slide controls. -Use push-button controls (one each for up and down). -Provide a keyboard equivalent for all controls.	-Easier use of controls for everyone. -Eventually lower costs.
8.1	Manuals Inability to handle or read the computer manuals (Item 8.1)	-Physically handicapped -Blind	Medium-high	-Provide the manuals in electronic form.	-It will soon be more convenient to carry around a disk containing the manuals than it will be to have the manuals available. Many manuals may, in fact, be stored in the corner of a hard disk. having them in electronic form also facilitates searching for particular topics or discussions in the manual, making them more useful.

SUMMARY OF DESIGN IDEAS

Below is a summary listing of ideas for inclusion in the Guidelines divided into 3 basic catagories. Those with an asterisk have not yet been covered directly in the Guidelines.

Design features that would increase the number of people who can use an unmodified computer.

1) Key shift lock option in software (for single key operation)
2) Power switch location
3) Key repeat rate adjustable
* 4) Keyboard equivalent for mouse commands
5) Disk drive design
6) Detachable keyboard (or connector for extra keyboard)
7) Tactile home and key keys (CONTROL, ESC, BACKSPACE)
8) Larger letters on keys
9) Better contrast letters on keys
10) Copy-protection relief
11) Redundancy of all audio information (e.g., also provided in visual form)
* 12) Volume control and headphones
13) Delay activation of keys (e.g., low pass filter)
* 14) Standardized switch connection (e.g., game paddles, etc.)
15) Built-in video zoom and scan
16) Simple open/close catches for foldable computers (one-finger, push motion)
17) Electronic form for manuals

Design features that facilitate the connection of special accessories or programs needed by more severely involved persons in order to use standard computers and standard software

1) Keyboard mounting dimples
2) Keystroke equivalent buffer in software (e.g., key stroke stack)
3) Access to the video signal
4) Access to the screen contents data
5) Alternate interface connector (standard or semi-standard)
6) Standard keyboard interface and connector (subset of alternate interface connector)
7) Mounting holes (tapped holes on bottom of computer)
* 8) Open architecture
* 9) Detailed information on all buses and connectors
* 10) Ability to support resident I/O routines
* 11) Contact reference point within company for technical questions from rehabilitation developers

Design features to facilitate the use of computers as special devices (e.g., to facilitate using the computer as a building block in the fabrication of a special device -- portable communication aid, portable braille writer/translator, etc.)

* 1) The size and shape of the computer (e.g. a computer which is flat when closed facilitates its use on a wheelchair laptray by not blocking forward vision.)
2) Ability to keep an inactive window always on the top of the pile (in order to have a keyboard in a window)
* 3) More expansion slots available
4) Voice synthesis built into the computer
* 5) Battery power built into the portable computer

GUIDELINES

FOR THE DESIGN OF COMPUTERS AND INFORMATION PROCESSING SYSTEMS

TO INCREASE THEIR ACCESS BY PERSONS WITH DISABILITIES

VERSION 2.0

APRIL 1986

PURPOSE AND ORGANIZATION

The purpose of the Guidelines is to document the best wisdom about the problems faced by individuals having disabilities when using computers and information systems, as well as possible solution strategies. This is done to facilitate the design of future computers and information systems; to allow their use not only by individual who are elderly or who have disabilities, but also to make them more useful to the general population.

The document is divided into two sections. Section I provides a brief overview of the different disability types, and the major impacts that these disabilities have on use of computers for each disability. This section is designed to provide an overall understanding of the disabilities with regard to computer use.

Section II contains a listing of problem areas and possible solution approaches. It is arranged by the part of the computer system involved (e.g., keyboard, monitor, operating system, etc.). After each of the problem/solution abstracts, there is an extended discussion (1-2 pages) which provides further information. There is a column along the right edge of each page for comments.

At the end of the Executive Summary is a section listing the design ideas for inclusion in the Guidelines. Please add items to this list, or make comments as to other items or ideas that should be included.

BACKGROUND ON THE PROJECT

In 1984, the Office of Special Education and Rehabilitation Services (U.S. Department of Education), in conjunction with the White House, took the initiative to begin a process of bringing computer manufacturers, developers and consumers together to address the question of access and use of standard computer and computer software by persons who have disabilities.

The first meeting of the initiative was held on February 24, 1984 at the White House. The objective of the first meeting was to familiarize the companies with the problem and to solicit their support for a cooperative effort to address the problem. The result of the first meeting was a recognition of the problem, and a request by the manufacturers for more information about the types of disabilities, the resulting barriers to the use of standard computers, and the types and scope of the solution strategies that the manufacturers were being asked to consider.

Subsequent to the meeting in February at the White House, briefings were held with manufacturers, and a White Paper was developed, distributed for comment, and revised and distributed in preparation for a second meeting held on October 24-25, 1985. This meeting consisted of a one and one-half day work session followed by a reporting session at the Rayburn Building on Capitol Hill. Computer firms represented included Apple, AT&T, Digital Equipment Corp., Hewlett Packard, Honeywell, IBM, and Tandy (Radio Shack).

One of the four results of this meeting in October was the formation of a task force to identify, refine, and document ideas and guidelines for the design of standard computers to increase their accessibility by disabled and non-disabled people. This group is open to any researchers, manufacturers, and consumers who want to work with this group. The objective of this cooperative industry-rehabilitation group is to develop materials for industry that can be used to improve the design of computers so that they will be usable by a larger portion of the population. The primary focus of this task force is the development of the design guidelines (this document). This will include information regarding the disabilities, their impact, the specific problems currently encountered, future anticipated problem areas, and existing or suggested design strategies as they are identified.

The overall computer access effort is being coordinated by the Electronic Industries Foundation and the Trace Center at the University of Wisconsin-Madison and is supported by grants G008300045 and G0083C0020 of the National Institute of Handicapped Research (OSERS - Department of Education). The guidelines task force is being coordinated out of the Trace Center.

SECTION I - DISCUSSIONS BY DISABILITY AREA

MOVEMENT DISABILITIES

VISUAL IMPAIRMENTS

HEARING IMPAIRMENTS

COGNITIVE DISABILITIES

DISCUSSIONS BY DISABILITY

There are many ways of grouping individuals with disabilities. The following categorization is used in this report to facilitate discussion of the ramifications of computer/software design and solution strategies.

I. Movement Disabilities
- A. Restricted but normal motor (i.e., muscle) control
  - Spinal cord injury
- B. Weak or limited range of movement
  - Spinal cord injury
  - Brain trauma
  - ALS (Amyotrophic lateral sclerosis) (Lou Gerhig's disease)
  - MS (Multiple sclerosis)
  - MD (Muscular dystrophy)
  - Polio
  - Orthopedic disorders
- C. Interference with motor control
  - Cerebral palsy

II. Visual Impairments
- A. Acuity (low vision)
- B. Processing (perception)
- C. Color blindness
- D. Blindness

III. Hearing Impairments
- A. Acuity (hearing loss)
- B. Processing
- C. Deafness

IV. Cognitive Disabilities
- A. Learning disabilities
- B. Retardation
- C. Integration
- D. Processing (dyslexia)

MOVEMENT DISABILITIES

For individuals with movement disabilities, it is the input mechanisms (e.g., keyboards, mice, etc.) to the computer that present the greatest problems. Also involved, but generally of less concern, are adjustments or other controls that may be on the computers or displays. In addition to difficulties in using the computer itself, individuals with movement disabilities may also have difficulty in manipulating many computer-related materials such as disks, printouts, etc.

Individuals with weakness or mild to moderate movement disorders may be unable to use standard keyboards, but are often able to use adapted or miniature keyboards. Individuals with high spinal cord injuries (no control below the neck), as well as individuals with extreme interference or weakness of their motor control systems, are often unable to use a keyboard of any kind. They are, however, able to use other special adaptive aids that could be used instead of the keyboard (mice, etc.) if there was a mechanism to connect them.

These alternate input mechanisms include sip-and-puff Morse code, voice recognition, scanning techniques requiring only the ability to activate a single switch, and eye-gaze keyboards that "type" when the individual simply looks at the "keys." These interfaces exist commercially, but there is currently no way to allow them to be used instead of the standard keyboards on unmodified computers running regular software.

As newer interface technologies appear (mice, touch screens, lightpens, touch pads), these problems take on new dimensions. Alternate access mechanisms need to be developed for all of these input approaches if individuals are to have access to standard educational, recreational, and productivity software.

VISUAL IMPAIRMENTS

Visual impairments fall into four general categories:

1) visual acuity
2) visual perception
3) color blindness
4) blindness

People with VISUAL ACUITY impairments have difficulty seeing at a distance, close up, or focusing the image. These individuals have the greatest difficulty with the displays on computers (CRT's, LCD's, etc.). The small lettering on some of the newer keyboards, however, also poses a problem for individuals with limited visual acuity. With the aging of the computer-using population, problems in visual access will be of increasing concern. Availability of optional large-screen displays helps somewhat with personally-owned systems, but does little for the larger problem of access to computers in public, educational, and employment settings.

VISUAL PERCEPTION PROBLEMS are the problems faced by individuals whose eyes focus well, but who have visual processing difficulties that make it difficult or impossible to handle printed information or complex displays. This is more of a software design issue than a hardware or system access issue. Simpler, larger displays may help on systems to be used for the public, as would some of the solution strategies for totally blind individuals.

COLOR BLINDNESS will pose increasing problems as color displays are increasingly used. This, too, is largely a software question, although alternate display options could be of benefit. The problem is best addressed by careful selection of colors which appear different in shade to color blind individuals, or through redundant cues.

BLINDNESS, of course, presents severe problems for using regular software, due to the high reliance of the software on the visual display of information. Alternate display approaches (voice and Braille, most notably) exist, but usually cannot be used to access the screen images produced by standard software without modifying the operating system or the computer itself. Manuals and information on how to use these systems and software are usually not available in a form that is usable by blind individuals (e.g., in Braille or on disk).

HEARING IMPAIRMENTS

Individuals with hearing impairments are not currently at a great disadvantage when trying to use standard software packages. Some warnings that appear only as sounds or tones are a problem. Warnings that are both visual and auditory generally are not a problem -- especially if the visual warning is difficult to miss. Some newer programs that use speech as output or to guide or assist the user do pose a significant barrier when the information is not also provided in visual form (e.g., on the screen). Public access computer system developers (information systems, etc.) may want to note that English is a second language to many deaf individuals who communicate in American Sign Language (which is a totally different language from English).

COGNITIVE DISABILITIES

The problems of persons with disabilities in this area generally affect the design of software programs, rather than the hardware or operating system architecture. Specific learning disabilities, memory problems, and retardation are examples of disabilities from this category. Each of these disability areas, however, is very distinct from the others, and poses different constraints. Public access systems in particular may want to consider the complexity of keyboards and visual displays, memory requirements (on the part of the user), and the cognitive demands of their programs and systems. Clear, simple, step-by-step directions and operation are important, as is the lack of clutter on screens. All of these measures also increase the ease of use of systems by the elderly and by the general public.

SECTION II -- PROBLEM/STRATEGY DESCRIPTIONS

(by computer part)

1. OPERATING SYSTEM
2. KEYBOARD
3. OTHER INPUT DEVICES
4. DISPLAY SCREEN
5. OTHER OUTPUT DEVICES
6. MECHANICAL DESIGN
7. APPLICATION SOFTWARE
8. DOCUMENTATION
9. ADVERTISING

ALTERNATE INPUT

PROBLEM:

Inability to connect alternate input devices

WHO:

- Anyone unable to use the current input devices (keyboards, mice, touchscreens, joysticks, etc.)
- People who would be much faster using another input device
- People who need a more rugged input device
- People who are blind (allows use of standard keyboard format, braille, or auditory feedback keyboard)

PRIORITY:

High priority -- it is feasible and economical to make computers accessible by everyone, including individuals with severe disabilities. These individuals could use standard computers and information systems if there was a means for them to connect their own, specially developed, input device (keyboards, mice, touch screens, touchpad, and joystick equivalents) to the computer.

POSSIBLE DESIGN APPROACHES:

1. Provide an entry point in the operating system that is treated exactly like the keyboard (mouse, etc.) even at boot time.
2. Increase standardization of keyboard connectors (fewer variations)
3. Provide a standard or semi-standard alternate access connector (through which alternate keyboards, mice, voice activated keyboards, etc., could be connected) that would be treated exactly like input from the keyboard.

IMPACT ON MASS MARKET:

- Increased ability of third-party vendors to produce alternate input devices (voice input keyboards, touchpads, mice alternatives, etc.) that could be more easily connected to different computers within a single company's line, as well as across computer companies.

DISCUSSION

This is perhaps one of the most difficult and most important item in this Guidelines document. It is simply not feasible or rational for computer companies to attempt to make computers that can be accessed by everyone. Individuals with more severe disabilities will require custom or semi-custom interface mechanisms to allow them to access computers. These interfaces include voice input keyboards, eyegaze keyboards, sip-and-puff morse code keyboards , head-motion-operated keyboards, as well as a similar range of mouse replacement and touchscreen equivalent input devices.

These more severely physically handicapped individuals, however, will need to access standard computers and standard software just as much as anyone else in their school, work place, library, or other community settings.

The only reasonable approach to providing this access, therefore, is to assume acquisition by the individuals of any specialized input interfaces that they require, and to have computer manufacturers simply provide a mechanism for attaching these alternate input interfaces in lieu of the keyboard. For this approach to work, the computer would have to treat these alternate input systems exactly as it treats input from the keyboard under all circumstances, even during boot-up time.

One approach that has been used to date is to simply make the alternate input devices look electrically identical to the computer's regular keyboard at the connector. These alternate input devices can then be plugged into the computer instead of the computer keyboard. Although this approach works for an individual with his own personal computer, it does not allow the individual access to the different computers that he or she encounters in schools, jobs, and other settings. Different classrooms use different computers, and different models of the same computer. The keyboard connection varies electrically as well as physically among these different computers. For example, the IBM PC and IBM AT keyboards are incompatible with each other, as well as with the IBM PCjr and all other IBM computers. The Apple II+, IIe, and IIc similarly have keyboards that are incompatible with each other. In addition, the keyboard connectors are not even available externally.

One suggested approach is to have the operating system designed such that input from a serial port could be handled in exactly the same fashion as input from the keyboard, mouse, etc. This would provide the needed standard input system across computers. Even if the information which was to be sent to the serial port varied between different computer manufacturers or computer models, the bulk of the interconnection problem would be solved. The disabled user would simply have to reconfigure his or her intelligent keyboard slightly to interact with different keyboards and input systems having different numbers of keys, operating characteristics, etc.

One problem with this approach is that many smaller or more portable systems have a single serial port. The increasing tendency to have multiple serial ports, the introduction of SCSI and other daisy chain input approaches, and the possibility for a standard daisy chain type alternate access input connector or capability may provide some new avenues for addressing this problem.

An alternate access input connector refers to the provision of a generic input connector that might be provided on future computer systems. Rather than being designed to handle a specific type of input device, the connector would be designed to support different categories of devices. These categories might, for example, be discrete ASCII signals (such as that which might come from a keyboard), relative movement signals (such as that which

might come from a mouse or mouse replacement), and absolute position signals (such as that which might come from a touch screen, touch tablet, or 3-dimensional position indicator). Such a connector would facilitate the use of a wide range of third-party special keyboards and input devices with any given computer or software package.

If such a connector allows daisy-chaining, different users would be able to select the particular input device or system that they found easiest or most convenient. These users could include able-bodied and disabled individuals alike. Again, the individual input transducers would probably have to be configurable to some extent, to accommodate the specific computer with which they are to be used. It is unlikely that any standardized number of keys, key layout, or resolution (touchpads, etc.) will ever be achieved across computers.

Either of the above two approaches requires that a point exist in the computer's software architecture where input from various input devices would all be treated identically. If this point existed, it would also allow other software routines running in the computer (in a background or multi-tasking fashion) to inject "keystrokes" into the system in the same fashion as an external input system (see Item 1.2). A program running internal to the computer could then be interpreting movements of a disabled individual on a simple transducer, determining the desired "keystrokes," and then feeding these keystrokes to this "alternate access" point in the operating system as if they were coming directly from the keyboard. This approach would generally only be used in the individual's own personal computer, or computers for which he/she is allowed to load or modify the software. Thus, this approach might be very useful in giving a user inexpensive access to his/her own computer. Approaches similar to this last one, however, do not address the problem of access to distributed computers at the job site, school, or in the community, since the user will not have the ability to load custom input software into these computers. They will therefore have to use external interface systems (which may themselves be small computers) to access the "public" computers through one of the first two mechanisms described above.

NESTED ROUTINES

PROBLEM:

Inability to nest access routines in the computer

WHO:

- People with all types of disabilities, as well as non-disabled persons

PRIORITY:

High priority -- provides tremendous potential for installing custom routines to lessen the problems faced by people when using computers. These individual may have a wide range of disabilities.

POSSIBLE DESIGN APPROACHES:

1. Provide a point in the operating system where a program running in background or multi-tasking can inject keystrokes or other input signals which will be treated precisely like input from keyboards, mice, etc., under all operating conditions.
2. Provide an "input" window capability as well as active and background windows.

IMPACT ON MASS MARKET:

- Has wide-ranging implications for specialized input technique or processing algorithms.

DISCUSSION

See Discussion or Item 1.1, especially approach 3, regarding input.

This capability also could facilitate use of the computer by persons of other types of disabilities besides physical handicaps. For example, blind individuals could have special talking keyboard programs that would run between the keyboard and the software in a nested fashion. Input systems that included word cuing, etc., could be provided for learning or language impaired individuals.

SHIFT/CTRL KEYS

PROBLEM:

Inability to hold down a shift or control key and another key at the same time.

WHO:

- People with only one hand
- People who use a single finger, headstick, mouthstick, etc., to type.
- Anyone who temporarily loses the use of one arm.

PRIORITY:

High priority -- a primary barrier for a large number of mild to moderately impaired individuals.

POSSIBLE DESIGN APPROACHES:

1. Provide an optional tri-state latching of the shift, control, and similar keys. Tri-state latching can be built into the software or firmware of the computer or keyboard.

IMPACT ON MASS MARKET:

- Easily called up or disabled at the option of the user, with auto turn off for able-bodied users.
- Able-bodied user may find it convenient to operate the keyboard with one hand when using the other hand to handle books or keep place in charts.

DISCUSSION

The basic problem here is keyboards that require concurrent activation of multiple keys, especially when these keys are not adjacent to each other. Many individuals, either temporarily or permanently, do not have use of both of their hands. They are not otherwise handicapped in their use of computers or of the keyboard (it is possible to type at 80 words per minute with one hand).

Mechanical hold-down clamps to latch keys can be fitted to the individual's personal computer. This does not, however, facilitate their use of the growing number of computers that they encounter at work and in their daily environments that they cannot physically modify. It is also difficult to find and mount mechanical key latch mechanisms for many of the keyboards, especially those that have other keys (e.g., function keys) adjacent to the shift and control keys. Finally, it is difficult for disabled individuals to share computers with their able-bodied peers if mechanical key latches are used, since it interferes with the able-bodied person's use of the keyboard.

Software patches to the operating system of some computers have been developed that change the way that the computer treats depressions of the shift key, so that an individual can depress the shift key first and then the key to be shifted. The computer holds the "shift state" for one key press, and then releases it back to the unshifted state. Hitting the shift key twice in a row causes the computer to lock in a shifted state. A third depression of the shift key unlocks the shift. Identical treatment is given to the CONTROL, ALTERNATE, and other similar keys.

In order to prevent interference by the program for able-bodied users, one version of this program, available for the IBM PC (Trace Center), is designed to be turned on by tapping the left shift key four times in succession. The program can similarly be disabled by tapping on the right shift key four times in succession. The program can also be set to automatically drop out after a period of inactivity on the keyboard (option) or whenever a shift key and any other key are depressed simultaneously (option). This latter feature causes the program to automatically disappear if an able-bodied individual sits down and begins to use the keyboard. The program/feature can thus be there for any disabled (or able-bodied) person who needs/wants it without interfering with or confusing other users who do not want it or even know that it is there.

NOTES

This strategy only works with computers that carry out the shift functions as a part of the operating system. Computers such as the Apple IIe carry out the shift encoding as part of the hardware. As a result, it is not possible to monitor the operation of the shift keys from software.

Some software packages such as TopView use depressions of the control key by itself to toggle the system back and forth. The keylock software program described above will work with TopView, since pressing the control key three times will have exactly the same effect as depressing the control key once without the program. The handicapped user would have to be aware of this difference, but it would not affect normal users' operation of TopView.

KEYBOARD POSITION

PROBLEM:

Inability to position the keyboard

WHO:

- Physically handicapped individuals, particularly individuals in wheelchairs.

PRIORITY:

Medium-high priority

POSSIBLE DESIGN APPROACHES:

1. Detached or detachable keyboard.
2. For non-detachable keyboards (including portables), provide a keyboard connector on the computer so that a separate keyboard can be connected.
3. Wireless keyboard.

IMPACT ON MASS MARKET:

- This facilitates access and comfort of users.

DISCUSSION

There are many individuals who are able to use the standard keyboard, but require that the keyboard be able to be placed in a certain position. If the keyboard is firmly attached to the computer, the individual must move the whole computer. This is not always possible either because the computer is chained down for security purposes, or the weight and shape of the computer precludes placing the keyboard in the orientation required.

Individuals who use a head stick or a mouth stick may have difficulty using a keyboard if it lies flat. Due to limited range of motion with their head, they have difficulty reaching the upper left and upper right keys. They may also have difficulty pressing straight down on the keys. If the keyboard can be tilted and positioned toward the individual at a 30-45 degree angle, both these problems are minimized.

Other individuals must put their body in a particular or supported position to be able to use the keyboard. This sometimes means that their body ends up in an unusual orientation. It is therefore crucial that the keyboard can be positioned in an orientation which matches their hand/arm position.

Individuals who use wheelchairs are sometimes unable to get up close to the edge of a table. It is therefore necessary that the keyboard can be placed on their wheelchair's lap-tray or on the individual's lap.

Having a detachable keyboard or a wireless keyboard would also facilitate the connection of specialized keyboards (e.g. eye operated keyboard) required by some disabled persons (see Item 1.1 and 1.2).

KEYGUARD

PROBLEM:
Inability to accommodate a keyguard

WHO:
- Physically handicapped individuals

PRIORITY:
Medium priority

POSSIBLE DESIGN APPROACHES:
1. Provide space inside case (laptops and portables).
2. Provide mounting points on keyboard.
3. Provide keyguard as special accessory.

IMPACT ON MASS MARKET:
- This would facilitate special overlays as well as keyboard masks for use in special applications or with young children.

DISCUSSION

Many individuals find it easier to use keyboards if they have a keyguard on them. A keyguard is a plate that is mounted above the keyboard, and which has holes in it above each key. Individuals with movement interference disorders can slide their hands on top of the keyguard, and brace against the keyguard to stabilize their motions. They can then poke their finger down through the keyguard to activate the desired key without accidentally activating any of the neighboring keys. Some (but not all) individuals who are weak find that the ability to rest their hands on the keyguard facilitates their ability to type. Similarly, some individuals who use headsticks, particularly those with movement disorders, find that a keyguard helps their speed and accuracy in typing. For these individuals, access to the computer can be provided if the shift key problem is addressed (see Item 2.1) and a keyguard can be provided for the computer.

For individuals who have their own computer, mounting systems can be permanently attached to the computer and the keyguard mounted to them. This can be a permanent mounting, where the keyguard is bolted firmly to the keyboard, or a mechanism whereby part of the mounting system stays on the keyboard but the keyguard can be easily removed and replaced as it is needed.

Situations arise, however, where a disabled person may want to use a keyboard but is unable to bolt a special mounting system to the computer keyboard. This is usually because the owner of the computer does not want to have the permanent mountings on the keyboard. This problem would be facilitated if small mounting clips or tapped holes were available on the keyboards and could be used for attaching special keyguards.

For portable or lap computers, which fold up into themselves, it would also be helpful if space were available in the cases to accommodate the keyguards which are required by some of these users. At present, it is often necessary to remove the keyguard in order to close the computer up. In order to use the computer, the individual must then open the case, remount the keyguard, etc.

Finally, it would be helpful if keyguards were made available by the manufacturer, either directly or through a special distributor, to facilitate their access and compatibility with the manufacturer's other accessories.

FINDING KEYS

PROBLEM:
Difficulty in finding keys without looking

WHO:
- Blind individuals
- Touch typists

PRIORITY:
Medium priority

POSSIBLE DESIGN APPROACHES:
1. Place nibs either on the top or the front edge of strategic keys such as the D, K, BACKSPACE, DELETE, and ESCAPE keys.
2. Standardize the position of more keys, especially BACKSPACE, DELETE, and ESCAPE.
3. On public information systems, have a HELP key with a distinctive tactile feel.

IMPACT ON MASS MARKET:
- It would make it easier for touch typists to use peripheral keys.
- On information systems, this can facilitate their use by individuals not familiar with them.

DISCUSSION

Nibs are commonly placed on the two keys in the home row, to facilitate finding these keys for touch typists. Some individuals, however, do not like the feel of a nib in the middle of the key. Nibs have also been placed on the very front edge of the key, where they can also be easily felt but are not directly underneath the fingertips while typing. Nibs placed on the front edge of the keys can also be more easily removed on personal computers when they are not desired.

In addition to the home keys, however, there are also a number of other very commonly used peripheral keys. These include BACKSPACE, DELETE, and ESCAPE keys. It would be helpful to blind (and other) typists if a small nib were placed on these keys as well to facilitate their location. This is especially true since their exact position tends to vary slightly from keyboard to keyboard.

It would also be helpful if the position of more keys were standardized. Many keys have an almost standard position, but even these keys move on some keyboards (the LEFT SHIFT, TAB, ESC, BACKSPACE, and RETURN keys).

On public information systems, it might be helpful to have an information HELP key. This key would have some distinctive tactile feel. When the key is depressed, the system might say "This is a help key. Holding this key down while pressing any other key will cause a description of that key to be read aloud. In order to activate that key, however, this information key must be released first."

Blind, low-vision, dyslexic individuals and other individuals who have difficulty reading could use this key to either determine or confirm the purpose of any given key or keys. Non-disabled individuals would also be able to use this key in order to get a more complete explanation of a particular button on the panel. Use of this key would also eliminate the need to have extensive Braille instructions describing the operation of the device as well as the location of each key.

SEEING KEYS

PROBLEM:

Inability to see the labeling on the keys

WHO:

- Individuals with low vision.
- Elderly individuals
- Individuals with movement disorders who have difficulty holding their head still

PRIORITY:

Medium priority.

POSSIBLE DESIGN APPROACHES:

1. Use larger letters on the keys.
2. Use higher contrast colors.

IMPACT ON MASS MARKET:

- Reduces eyestrain.
- Reduced visual complexity of the keys may be less threatening to non-technophiles.

DISCUSSION

Originally, keyboards were labelled with large letters, usually white on charcoal gray keys. More recently, the letters have gone to white on gray and other low contrast combinations, making it more difficult to read them. At the same time, the letters have been reduced in size and moved to the upper left-hand corner of the keys, further aggravating the problem.

Some of this has been in response to an ANSI standard that attempted to establish a standard way for placing multiple legends on a single key. As part of the standard, it was determined that the principal character would be placed in the upper left-hand corner. On most keyboards, however, there is only one legend on the key. When there is only one character on the key, there is no reason that it needs to be placed in the upper left-hand corner with the rest of the key left blank. If other legends are added to the key, it would usually be done by changing the keycap or by use of a sticker. In either case, the principal character could be reduced in size and moved to the upper left-hand corner at that time.

Whenever there is only a single character printed on a key, therefore, it should be possible to have that character printed in the larger size and with sufficiently contrasting colors to allow it to be easily seen by individuals with low vision or head movement disorders.

If color coding is used on the keys, it is also recommended that the effects of the different types of color blindness on perception of the information on the keys be borne in mind.

KEY REPEAT

PROBLEM:

Unwanted multiple letters caused by the key repeat feature

WHO:

- Physically handicapped individuals with slow or irregular release times.
- Young children.

PRIORITY:

Medium priority.

POSSIBLE DESIGN APPROACHES:

1. Have user adjustable repeat key start-up and rate (should be always available).

IMPACT ON MASS MARKET:

- Would facilitate use of systems by young children.

DISCUSSION

Some computers have the key repeat feature implemented in hardware (e.g. Apple IIe). In these instances, it would be useful if a small PC-board-mounted switch or other mechanism were provided to allow the key repeat feature to be defeated. A lowest cost mechanism would be to simply have a break point provided in a circuit run on the PC board with appropriate tie-up resistor to allow the repeat key to be defeated for an individual computer. The next best approach would be to have a small switch or a location where a switch could be installed to allow the repeat feature to be turned on and off.

For systems that allow software modification of the key repeat rate, the minimum solution would be to have a small program that could be run which would defeat or alter the key repeat rate. A better solution would be to have this capability built into the "MODE" (for PC-DOS) or similar command of the operating system. The best approach would be to have the key repeat adjustment available from the keyboard on a real-time basis. Computers that have a "toolkit" of user-configurable features for the computer provide the optimal solution, particular if adjustments can be made from the keyboard or alternate access device (see Item 1.1).

The ability to adjust or defeat the key repeat rate can be very important for computers that are intended to be used by young children, who often lean on keys and can be confused by the effects of the key repeat. This is especially true if they are in menus at the time.

KEY DELAY

PROBLEM:

Unwanted keys due to the lack of a delay activation time

WHO:

- Physically handicapped individuals with erratic hand motion.
- Individuals with hand tremors.
- Young children.

PRIORITY:

Medium-low priority.

POSSIBLE DESIGN APPROACHES:

1. Have user adjustable activation delay before keystroke is accepted (should be always available).

IMPACT ON MASS MARKET:

- Could facilitate use of systems by young children.

DISCUSSION

Individuals with erratic hand movements or hand tremors get unwanted characters when using the keyboard because they hit a key twice or accidentally hit neighboring keys when moving toward the desired key. Some are able to remedy this problem by using a keyguard (see Item 2.2) but a keyguard may tend to slow them down. Keyguards also are not available on all the computers they must use.

A possible solution would be to allow the user to adjust the time a key must be depressed before it is activated. This would allow individuals to accidentally hit keys as long as they finally come to rest on only one key.

DISPLAY SIZE

PROBLEM:

Information on standard display for the computer is too small

WHO:

- Individuals with low vision
- Elderly individuals

PRIORITY:

High priority

POSSIBLE DESIGN APPROACHES:

1. Make the video signal available externally so that larger displays can be connected.
2. Use a larger screen as part of the computer system.
3. Provide a built-in zoom capability.

IMPACT ON MASS MARKET:

- Larger, clearer displays are easier for everyone to use.
- External access to the video signal is part of open architecture.
- Facilitates connection of larger displays and display printers as well as special purpose video processors.

DISCUSSION

This is not a problem for most computers, which do export their video signals. The Macintosh, however, did not provide any external access to the video signal, causing difficulties in this regard. External video signals can be used to connect larger video screens. They can also be used by specialized video processing devices that can do pattern recognition and provide the information in alternate formats (see also Item 4.2).

In addition to simply exporting the video signal, other software processing of the video image might be provided to help facilitate the use by individuals with low vision. One of these might be a zoom and scan capability. Briefly, this allows the characters on the screen to be expanded and scanned using a moving window. Bit-mapped screens on newer systems provide some interesting future potentials in this area. When exploring these potentials, however, it should be noted that having the ability to expand the characters only on certain screens or in certain programs is only of limited value to individuals with low vision, since they really need to be able to see all of the messages and be able to use all of the features of the operating system.

Solution strategies that do not address 100% of the screen, however, are still useful. Especially for individuals with low vision, magnifiers and other

approaches can be used to cover seldom-used portions or operations that are only used for short periods of time if the longer use applications are usable.

SPECIAL DISPLAYS

PROBLEM:

Video display information is not provided externally for use by special display aids

WHO:

- Blind individuals
- Individuals with low vision.

PRIORITY:

High priority

POSSIBLE DESIGN APPROACHES:

1. Export a bit image of the screen for capture and reprocessing (especially for LCD displays).
2. Export the video signal for video image capture and reprocessing (see also 4.1).
3. Export the character content of the screen.

IMPACT ON MASS MARKET:

- As another extension of the open architecture concept, this allows for easier connection of alternate resolution displays and display printers, etc., for mass market.

DISCUSSION

There are a number of special expanded visual displays for low vision computer users. These systems take the text content of the screen and create an alternate text display. The characters on this display can be enlarged in stages to the point that a single character fills the screen. The characters are also made solid, and shaped in such a way that they are more easily processed by individuals with visual impairments. They also provide automatic scanning, so that reading off the end of one line automatically puts the reader at the beginning of the next (e.g., the end of Line 1 rolls of the left edge of the screen, and the beginning of Line 2 rolls on from the right edge of the screen, in line with the end of Line 1). In order for these systems to work, however, access is needed to the contents of the computer's video display.

Similarly, there are a number of Braille and voice output systems that have been and are being developed for blind individuals. These systems allow the blind individual to "read" the contents of the computer screen. At the present time, these systems are limited to text information. Attempts are being made, however, to also attack the question of graphic information and bit-mapped displays.

All of these systems, however, require access to the contents of the screen display. As a result, most systems are designed so that they only

work with a single model of a single computer. As computer models change, and as companies change the computer systems or displays that they are using, blind individuals find themselves constantly in a position of losing access to computers, and having to purchase a new system or wait for a special device manufacturer to come out with an updated version that can handle the latest computer(s). Since this can process can lag behind computer introductions by as much as a year, blind or low-vision computer users can find themselves in an untenable position.

One mechanism for providing general access to computer displays would be to simply tap the video signal (see 4.1). Many newer computers displays are being introduced, however, which do not involve a video signal (LCD, electroluminescence, plasma, etc.). As these displays move from portable to stationary systems, the problem may increase, further aggravating this situation. The use of these special display systems for blind and visually impaired individuals would be greatly facilitated if some standard mechanism for the output of the information on the video display were provided. Provision of the character information would be helpful. Alternately, a bit-mapped graphic image could be provided, which would then need to be analyzed externally to identify the characters, etc. The bit-mapped image format would also allow for future analysis of graphic information.

Either of the information export formats would assume that some type of standard or semi-standard procedure for exporting this information was developed.

Manufacturers of special displays for blind and visually impaired individuals have estimated that the cost for developing their products could be reduced by a third or more, and the time line for developing new products cut by half or more if such information were provided in a standard or semi-standard format from computers.

DISPLAY POSITION

PROBLEM:

Inability to position the display for easier viewing

WHO:

- Visually impaired persons
- Physically handicapped persons

PRIORITY:

Medium priority

POSSIBLE DESIGN APPROACHES:

1. Separate or movable display.
2. Connector to attach a movable display.

IMPACT ON MASS MARKET:

- Greater comfort and lower fatigue.
- Better adaptability to individual physical characteristics of users.

DISCUSSION

The ability to position the screen independent of the computer and the keyboard greatly facilitates setting up a computer system for the visually impaired or physically handicapped individual. The visually impaired individual needs to be closer to the display in order to see the display clearly and comfortably, so being able to move the display is helpful in a situation where this individual shares a computer with a non-visually impaired individual. Glare off of the display affects the visually impaired more than the non-visually impaired, so being able to position the display to reduce glare is very critical. Physically handicapped individuals need the freedom to place the computer where it can be best physically operated (e.g. disk insertion) and the display where it can be best seen. Often they need to have the computer very close to them due to limited range of motion, yet need the display at the normal viewing distance. It may need to be placed at the side of the bed but in a vertical position instead of a horizontal position so the individual may lie on his side.

Being able to position the screen also helps to reduce the glare for the non disabled individual. It also allows more functional use of the desk space by moving the bulk of the computer off the desk top and placing the display at a comfortable height above the desk top freeing up valuable desk space.

COLOR-ENCODED INFORMATION

PROBLEM:

Inability to distinguish some information presented through color

WHO:

- Color blind individuals

PRIORITY:

Medium priority

POSSIBLE DESIGN APPROACHES:

1. Be sure that all information that is contained in the color coded portions of the display information is also presented (or can be presented) in another way -- through capitalization, highlighting, position, etc..
2 User can select colors used on display.

IMPACT ON MASS MARKET:

- Redundant presentation of information facilitates speed in comprehension by all users.

DISCUSSION

If information on the screen is made distinct only by color, the color blind individual would not be able to make the distinction. It would be like trying to use a word processor in which a marked section of text was only distinguished from unmarked text by a 1/16 intensity change. For many individuals, this intensity change is imperceptible.

This issue is important if color is being used in a manner that is meant to provide some form of information which is not also presented or presentable in some other form.

AUDITORY OUTPUT

PROBLEM:

Inability to handle information presented auditorially

WHO:

- Deaf individuals
- Hearing impaired individuals
- Elderly individuals

PRIORITY:

High priority - The only major barrier to use of computer systems by the millions of deaf and hearing impaired individuals

POSSIBLE DESIGN APPROACHES:

1. All information provided auditorially is provided in a redundant fashion visually.
2. LED mounted prominently on the keyboard or display which could light up in parallel with the computer speaker (at the option of the user).

IMPACT ON MASS MARKET:

- Facilitates use of computers in noisy environments.
- Facilitates use of computers where computers are located immediately adjacent to each other, and origin of the sound may be ambiguous.

DISCUSSION

At the present time, deaf and hearing impaired individuals have little or no difficulty in using computers. Occasionally, beeps or other auditory signals are presented without any corresponding visual cue. For the most part, however, the auditory beep is accompanied by some type of visual message or signal.

As the use of speech synthesis advances, however, more programs may begin to include complicated auditory signals and/or speech as part of their program. As long as this is accompanied by a visual representation on the screen, it presents no problem. Beeps can be accompanied by having a brief word flash on the screen, or having a word flash in reverse. Messages could appear momentarily in message boxes or at the bottom of the screen.

If large volumes of information are provided auditorially that are not presented visually by the program, it would be useful if an optional feature were provided whereby the captions could be called up to the screen. Alternately, the information might be sent out a serial port so that deaf individuals could connect a separate display for the display of auditory spoken information. This latter approach, however, is the least desirable,

and would have many problems including: the need to have extra hardware attached to the computer; a port would have to be dedicated for this purpose so that is would always be available. Hopefully, either redundant display of information or the ability to optionally have spoken information presented on the screen can prevent problems from arising for hearing impaired individuals.

For the mass market, the ability to have the information presented visually as well as auditorially may be quite useful, especially for computer systems placed in libraries, open workspaces, and other areas where vocal output may not be desirable.

MODEM SPEECH

PROBLEM:

Inability to effectively use new speech capabilities of computers with their built-in modem

WHO:

- Speech impaired individuals.
- Blind individuals.
- Deaf individuals

PRIORITY:

Medium-low priority

POSSIBLE DESIGN APPROACHES:

1. Capability to direct speech through auto-dial feature in built-in modem.

IMPACT ON MASS MARKET:

- Opens up a wide variety of applications in stored speech messaging and combination text and speech capabilities.
- Facilitates personal messaging systems and timed message delivery systems, etc.

DISCUSSION

This is not a high priority item, since voice synthesizers are available that can be used with almost any computer. It is included here since built-in voice output capability is likely to continue to appear as a standard hardware capability in future computers (it is already available, for example, in the Macintosh). As it becomes available, it would be a shame if one or two minor features were left out or included that precluded or limited its use by disabled persons. This discussion space will be used to draw attention to such features.

One desirable feature would be the ability to connect the voice output capability through the auto-dialer features of the modem. This would allow speech impaired individuals to dial the phone and use the internal synthesizer to talk to people on the other end. This would include people who are speech impaired due to physical handicap and deaf individuals who do not have fully intelligible speech.

DISK DRIVE

PROBLEM:

In ability to insert and remove disks (and other media)

WHO:

- Physically handicapped individuals, including those with movement interference disabilities (e.g., cerebral palsy) and spinal cord injuries.

PRIORITY:

Medium-high priority

POSSIBLE DESIGN APPROACHES:

1. Frontal access to disk drives.
2. Avoid twist lock mechanisms on disk drives, which are difficult to operate.
3. Use low-effort mechanisms operable by a stick in one's mouth.
4. Use 3-1/2" disks (more stiff).
5. Use disk drives that "pop" the disks out, where they can be grasped more easily.
6. Use self-channeling disk drive openings which are difficult to wedge disks into.
7. Use hard disk loadable software to eliminate disk handling.
8. Use disk drives that can be positioned independent of the computer and display.

IMPACT ON MASS MARKET:

- Easier, more convenient disk drive operation by everyone.

DISCUSSION

Handling of disks is a major problem for individuals with many types of physical handicaps, as well as, to a lesser degree, individuals with visual impairments. There are basically three types of physical handicaps that affect the use of disks and disk drives: 1) interference, 2) weakness, and 3) limited range of motion.

Movement interference disabilities are those where the individual has full range of motion, but has erratic unpredictable movements superimposed upon the intentional movements. Cerebral palsy is the most common example in this area, although head injuries and progressive diseases can also result in similar disabilities. Individuals with cerebral palsy have difficulty in carrying out twisting motions, making twist lock mechanisms difficult. The handling of 5 1/4" disks, especially their insertion into the disk drive without bending them, is also difficult. Special racks have sometimes been constructed to facilitate lining up and inserting the disks. 3 1/2" disks are much easier. Drives that pop the disks outward to where they can be easily

grasped also greatly facilitate use of computers by these individuals, since it is often difficult for them to reach inside the drive to draw the disk out, as is usually required on the 5 1/4" drives.

Individuals suffering from weakness disorders are often unable to move their hands or arms more than a few inches from the edge of the table or desk. Examples in this category would be individuals with multiple sclerosis and muscular dystrophy, both of which are progressive neuromuscular diseases. Disk drives that can be moved up closer to the edge of the table, is therefore of assistance to them. This may require that the keyboard be detachable. Disks that can be handled sloppily and that require less physical control for insertion are helpful here as well as with movement impaired individuals (discussed above). Finally, drive systems that involve low physical effort to insert or eject the disks also facilitate these individuals' use of computers.

The third category of physically handicapped individuals are those who have normal but limited physical capabilities. High spinal cord injured individuals are the best example here. These individuals may have normal control of their head, and no control below that level. Individuals with lower spinal cord injuries may have characteristics that resemble both this category and the weakness category above. High spinal cord injured individuals very often carry out their computer operations using mouthsticks and other special manipulation appliances operated with their mouths. Inserting disks may be done with a mouthstick having a clip on the end of it, for example. As a result, side mounted disk drives and disk drives that involve twist locks are more difficult to them to handle. Similarly, it is often difficult to get disks out of the disk drive. A mechanism used by some individuals is to put a small tab of tape, with a hole punched through it, on the top edge of the disk. They are then able to use a mouthstick with a hook to catch the tab and pull the disk from the disk drive. Here again, 3 1/2" disks that are more rigid and require less careful handling are easier to use. If the disk drives can be moved independent of the screen or computer, they can be position in the vertical position so that the disks can be inserted much like one inserts bread into a toaster which is easier for some people. For the hook method, it is much easier to manipulate the disks if the tab can be placed in the middle of the top edge of the disk because of balance. However, many disk drives have clamps that come down in the middle precluding the placement of the tab in the middle.

With all of the above disabilities, the use of hard disks can greatly reduce the amount of disk handling that is needed. The ability to load software onto a hard disk for use, therefore, is of great benefit. Software that requires a "key disk" to be placed in the drive poses particular problems. This is especially true when the handicapped individual moves back and forth between different software programs and need to continually switch "key disks." A new system whereby the key disk need only be placed in the computer once every two weeks is much better. Systems that do not require any key disks are best.

Some computers allow the connection of external disk drives. These can be particularly useful, since it can allow the positioning of disk drives near

the edge of the table where they are more easily accessed. It can also allow the use of multiple separate disk drives to hold individual "key disks" for those software packages where this is required. It can also allow the individual to pre-load several different disks at the beginning of the day, avoiding frequent disk swaps for either data or program access.

POWER SWITCH

PROBLEM:

Inability to operate the power switch

WHO:

- Physically handicapped individuals
- Blind individuals

PRIORITY:

Low priority for individual systems, because plug strips can be used as a solution. Higher priority for public access terminals that would be turned off when the disabled user came to them.

POSSIBLE DESIGN APPROACHES :

1. Mount the power switch on the front of the computer.
2. Allow it to be operated with a push motion (mouthstick, etc.).
3. For visually impaired individuals, make it tactilely distinct and not easily activated (though not requiring great strength).
4. Have a computer which never completely turns off and can be activated, put to sleep, and reset from the keyboard or alternate keyboards.

IMPACT ON MASS MARKET:

- Easier to find power switch on mass market access systems.
- Provides greater flexibility in placement of computer components, since it is more difficult to accidentally block access to the power switch.

DISCUSSION

The ability to turn on the computer or public access terminals is very important if the terminals are ever turned off. On computers, it is sometimes necessary to turn the computer off and then on to recover from a crashed program.

A power switch at the front of the computer allows for easy access for individuals in a wheelchair who cannot reach around to the back of the computer, or for individuals who use headsticks or mouthsticks to operate the computer.

A power switch that is recognizable by touch facilitates locating the switch for visually impaired individuals

Another possible solution is to allow the computer to be turned on and off using the keyboard. Part of the computer would be on at all times, and would monitor the keyboard, or input device (see discussion in Items 1.1 and 1.2 on alternate access), for a turn on, or turn off, key or key sequence.

This would not only help those individuals who could only use the keyboard, but also for those who cannot use the keyboard and have a specialized input system. If keyboards were wireless (see Item 2.2), then these individuals would not even have to plug in their specialized input system.

LATCHES

PROBLEM:

Inability to open up and collapse computers (portable/laptop) due to latching mechanism design

WHO:

- Physically handicapped individuals

PRIORITY:

Medium-high priority

POSSIBLE DESIGN APPROACHES:

1. Design systems that do not require simultaneous release of two latches.
2. A latch setting that allows the system to be opened and closed without locking shut each time.

IMPACT ON MASS MARKET:

- Easier use of computer; easier opening and closing with one hand.

DISCUSSION

With the advent of laptop computers, many individuals with physical disabilities can now take their computers about with them for use as portable writing and communication systems. Individuals in power wheelchairs, however, need to collapse the display in order to see where they are going; they then need to open the display back up in order to write, or, if they are speech impaired, to converse.

Computers that lie flat are the best for these applications, since they present the least barrier to forward vision when they are closed. Such systems can be left on the laptray of a power wheelchair and opened and closed as they are needed.

Some computers are very difficult for disabled individuals to use, however, since closing them causes them to automatically lock shut. In addition, opening them requires, first, simultaneous activation of catches on both sides of the computer, and then lifting of the display. This is nearly impossible for all physically handicapped individuals. Also, the catches are very often located on the sides of the computer, making it difficult to even activate one catch (with the other one disabled). If the latches are recessed or flat which it is very difficult to gain any leverage, requiring great dexterity and finger strength.

Computers used in this fashion are generally dedicated to the handicapped user. As a result, some physical modification can be made to the catch to facilitate its use. Design of the catch to facilitate these types of

modification, or to facilitate direct use by disabled individuals, would greatly facilitate the use of these aids by disabled persons.

Push-button release catches located on the front edge of the computer are probably the easiest to use. Lids that pop up slightly make it easier for disabled persons to lift the displays into their upright, locked positions. Similarly, easy-to-operate release mechanisms for closing the displays are useful.

ATTACHMENT MEANS

PROBLEM:

Inability to attach things to the computer

WHO:

- People with all types of disabilities

PRIORITY:

Medium priority

POSSIBLE DESIGN APPROACHES:

1. Pre-tapped holes on the bottom (or back) of the computer to:
   a. bolt the computer to laptray, etc.
   b. bolt special accessories to the computer to make a single unit.

IMPACT ON MASS MARKET:

- Facilitates security mounting.
- OEM-VAR construction of special applications equipment.

DISCUSSION

Especially with the portable and lap computers, it is often desirable to attach things to the computer. Unfortunately, there is usually very little room in the computers to drill or tap holes. In addition, such modifications may void warranties, etc. Still, it is very useful to be able to mount things rigidly to these computers.

First, it is often desirable to mount lap computers securely to laptrays or other mounted platforms. This may be done both to protect the computer from being jarred loose and falling to the floor, and to prevent computer theft. A disabled individual driving down the streets of New York recently had a passerby lift the computer from his laptray and calmly walk away with it.

It is also often helpful to be able to bolt other special accessories to the computer. For blind individuals, this may be a special package of electronics that would bolt to the bottom of the lap computer to provide voice output and interpretation of the contents on the computer's text screen. For a physically handicapped individual, it may involve the attachment of an electronic module supporting special input interfaces, voice output, special wheelchair control drivers, wireless data link for environmental control, etc.

The provision of pre-tapped mounting holes in structurally appropriate places on the bottom, and perhaps the back, of the portable and lap computers would greatly facilitate these activities.

CONTROL KNOBS

PROBLEM:

Inability to operate controls requiring twist action.

WHO:

- Physically handicapped individuals (especially those who use a mouthstick or headstick)

PRIORITY:

Medium priority

POSSIBLE DESIGN APPROACHES:

1. Use thumbwheel controls.
2. Use slide controls.
3. Use push-buttons (one each for up and down).
4. Provide a keyboard equivalent for all controls.

IMPACT ON MASS MARKET:

- Easier use of controls for everyone.
- Eventually lower costs.

DISCUSSION

Many controls require the use of a variable resistor. Some familiar ones are brightness and contrast control for a monitor, viewing angle on LCD screens and volume control for a speaker. The user is normally required to turn a knob to adjust these controls. Some persons with physical disabilities are unable to perform the task of grasping and turning a knob. Some are limited to using a mouth stick or a headstick to manipulate controls.

There are many ways to provide a user with the ability to adjust a control without turning a knob that is being more widely used in the commercial and industrial market. Where potentiometers are required, thumbwheel or slide configurations require the least physical ability. Many televisions are being designed to allow a user to adjust the control by pressing and holding down a button to increase or decrease the volume and to change channels, all which previously required turning knobs. Similarly, radios design is going in the same direction. Most public facilities no longer use doorknobs on doors which requires easy and quick exit. It would facilitate the use of computers and accessories if the need to turn a knob were minimized.

MANUALS

PROBLEM:

Inability to handle or read the computer manuals

WHO:

- Physically handicapped individuals.
- Blind individuals.

PRIORITY:

Medium high priority

POSSIBLE DESIGN APPROACHES:

1. Provide the manuals in electronic form.

IMPACT ON MASS MARKET

- It will soon be more convenient to carry around a disk containing the manuals than it will be to have the manuals available. Many manuals may, in fact, be stored in the corner of a hard disk. Having them in electronic form also facilitates searching for particular topics or discussions in the manual, making them more useful.

DISCUSSION

Many physically handicapped individuals have great difficulty in manipulating the various manuals that come with computers. As a result, they may be able to operate the computer but not be able to learn it. If the manuals were provided in electronic form, however, the individuals would be able to access and read the manuals directly from the screen.

Blind individuals have an even more severe problem in that the print manuals are of no direct value to them. Often, however, they do have voice output or Braille display attachments on their computer that would allow them to access the contents of the manuals if they were provided in electronic form.

In preparing manuals, the effects of various types of color blindness on the interpretation of the information presented should also be kept in mind.

If the manual is available in an electronic form, it should be clearly and prominently indicated on the cover.

APPENDICES

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